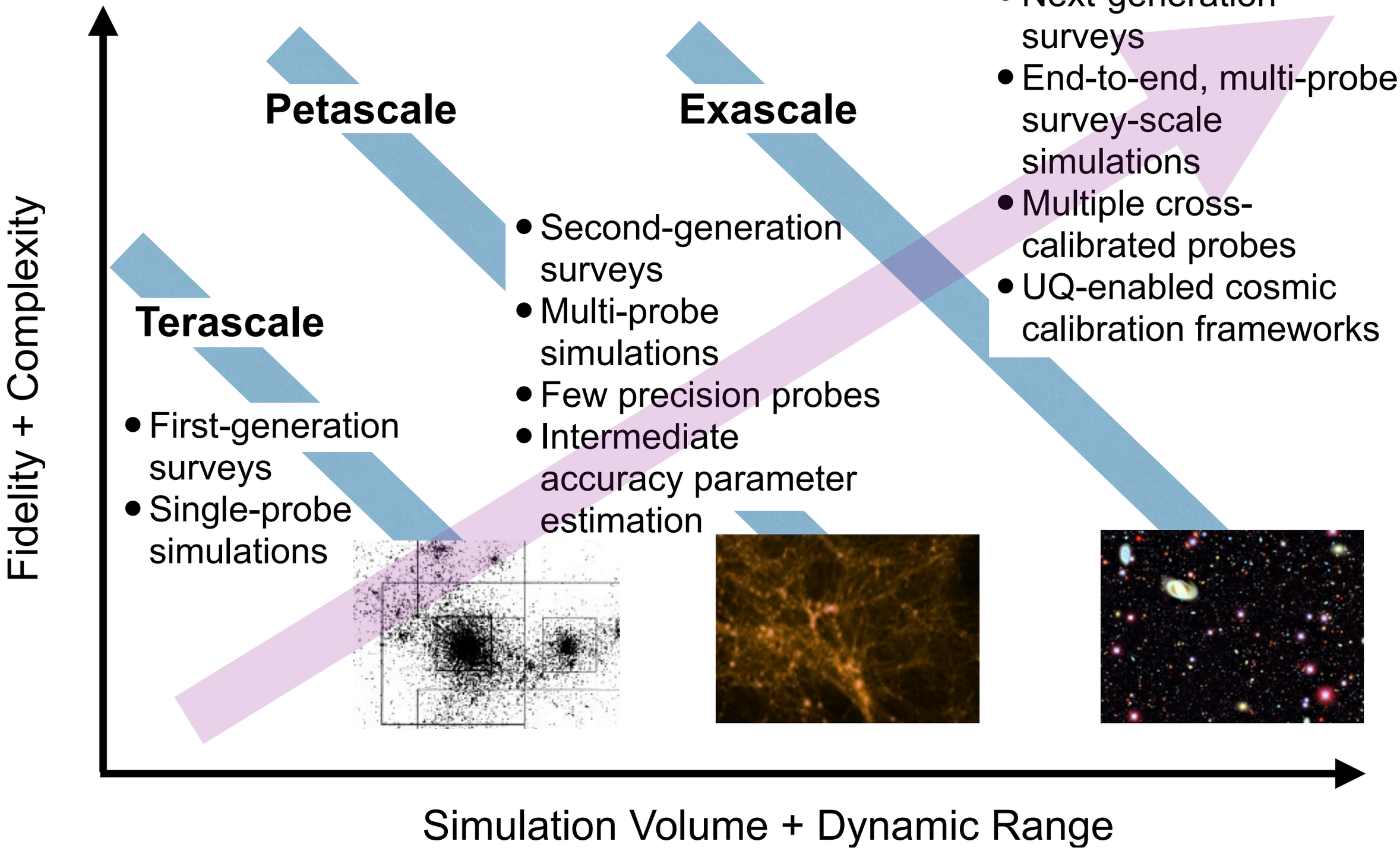
Cosmology: Simulation Frontiers



‘Big(ish) Data’ Meets Supercomputing

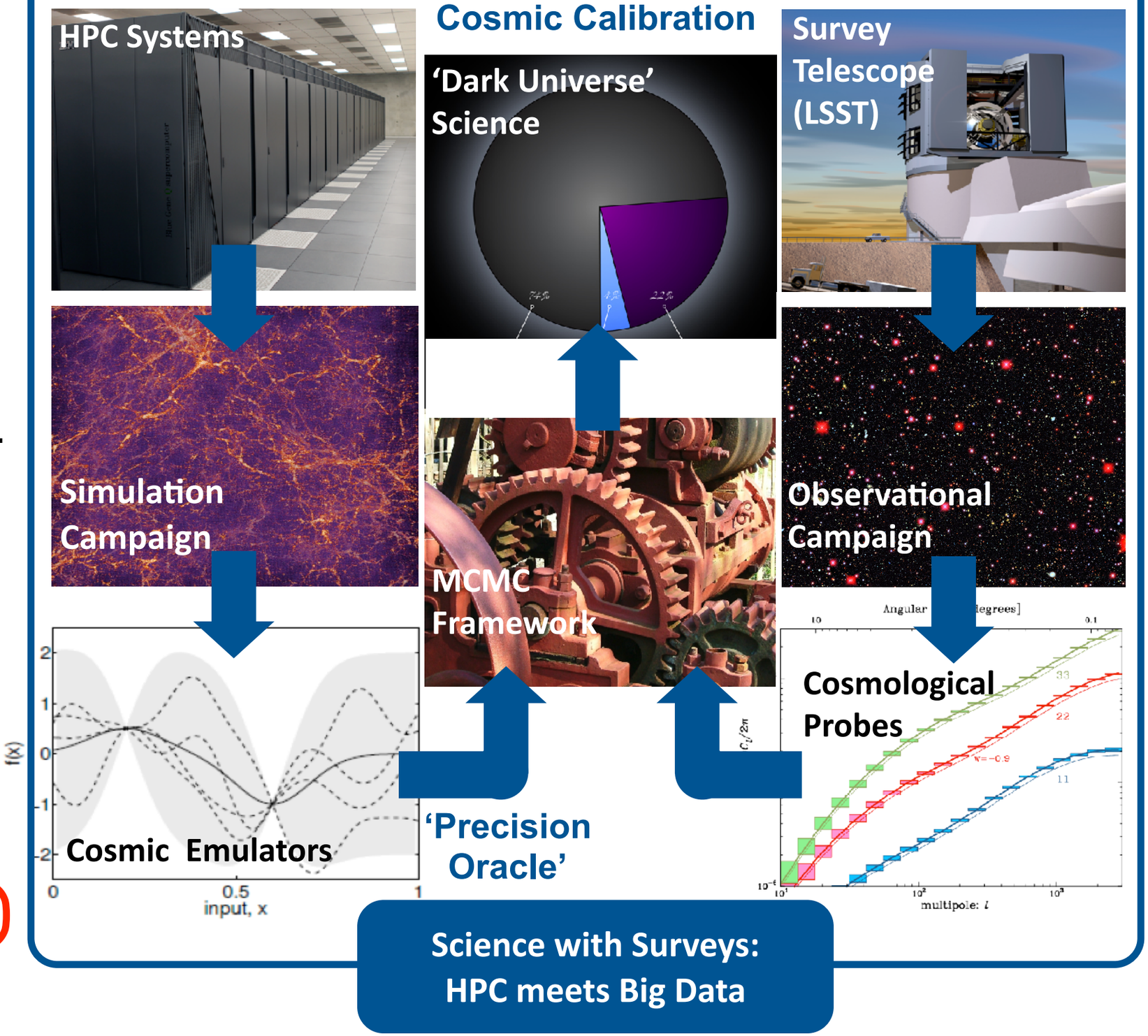
Supercomputer simulation campaigns

Weeks per simulation!

Statistics + machine learning + optimization methods

Emulator based on Gaussian process interpolation in high-dimensional spaces

sub-milliseconds!



Mapping the sky with multiple survey instruments

Extraction of summary statistics from survey sky maps

Observations: Statistical error bars very small, systematics dominate

Computational Cosmology Challenges

Next-Generation System Architecture

- Complexity at the node level (heterogeneity, accelerators, —)
- Multi-level memory hierarchy (limited DRAM/core) including NVRAM
- Skewed compute/communication balance (‘weak’ networks — PCIE, IB)
- Programming models, portability

Improved Physics

- More accurate simulations for known physics (e.g., neutrinos, radiative transfer)
- Higher fidelity phenomenological inputs (e.g., galaxy formation)

Analysis/Workflow Complexity

- Realistic forward modeling of observations
- Data-intensive computational challenges
- AI/ML-based inverse problem treatments